

SPECIFICATION

TITLE OF THE INVENTION

Transmitter and Method of Transmission

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BACKGROUND OF THE INVENTION

1) Field of the Invention

The present invention relates to transmitters and a method of transmission that are used in a network where data packets are transferred between a source transmitter and a destination transmitter via a relay transmitter, and relates more particularly to transmitters and a transmission method that are suitably employed in a vast and complex network where data transmission between certain points is performed via a redundant path structure (consisting of a plurality of paths) to ensure reliability.

2) Description of the Related Art

In networks, in which transmission path ports in transmitters are connected through transmission paths such as optical fiber paths, data communications is performed between transmitters.

In a first method of transmission, it is judged whether a data packet received by one transmission path port in a transmitter is relayed to another transmission path port which relays the received data packet to its destination, and based on the result of judgement, the received data packet is relayed from the receiving port

to the relay port. In a second method of transmission, a transmission path port to relay a data packet is determined by referring to a routing table, based on a destination address contained in the header of a data packet.

5 A conventional transmitter adopting the above-described first transmission method is shown in Fig. 12 by way of example. The conventional transmitter is typically configured to include receiving port sections 111, 121, 131, 141, transmitting port sections 112, 122, 132, 142, and a relay section 150.

10 The receiving port sections 111, 121, 131, and 141 consist of O/E (Optical/Electrical) converters 113, 123, 133, 143, reception controllers 114, 124, 134, 144, and first-in first-out (FIFO) memories 115, 125, 135, 145, respectively. The transmitting port sections 112, 122, 132, and 142 consist of transmission controllers 116, 126, 136, 146, FIFO memories 117, 127, 137, 147, and E/O converters 118, 128, 138, 148, respectively.

20 The relay section 150 consists of relay units 151 to 154, which relay packets received via the receiving port sections 111, 121, 131, and 141. The relay units 151 to 154 store the connection status of the transmitting port sections 112, 122, 132, and 142 to which a received packet is transmitted from the receiving port sections 111, 121, 131, and 141. This makes it possible to relay a packet received via the receiving ports 111, 121, 131, or 141 to a relay transmitter from which the received packet

reaches its destination (destination transmitter).

For example, in the case where transmitters 1-1 to 1-n (where n is an integer ≥ 3), 2-1 to 2-4, 3-1, and 3-2 such as the one shown in Fig. 12 are arranged as shown
5 in Fig. 13 and construct a network 4, packets are transmitted within the network 4 by the above-described first transmission method. In the relay units 151 to 154 of the relay section 150 in each of the transmitters 1-1 to 1-n, 2-1 to 2-4, 3-1, and 3-2, relay methods in the
10 transmitting and receiving port sections 111, 121, 131, 141, 112, 122, 132, and 142 are set.

The network 4 consists of three network portions, depending on the form of connection of transmitters. The first network portion 1 consists of transmitters 1-1 to
15 1-n connected in tandem, the second network portion 2 consists of transmitters 2-1 to 2-4 connected in ring form, and the third network portion 3 consists of transmitters 3-1 and 3-2 connected in tandem. The transmitter 1-n and the transmitter 2-1 are connected to each other, so the
20 first network portion 1 and the second network portion 2 are connected to each other. The transmitter 2-4 and the transmitter 3-1 are connected to each other, so the second network portion 2 and the third network portion 3 are connected to each other.

25 The transmitter 2-1 is constructed so packets can be relayed according to settings shown in Fig. 14 by the relay units 151 to 154 of the relay section 150. Note

in the figure that the transmission path ports 110, 120, 130, and 140 of the transmitter 2-1 are provided with transmitting and receiving port sections 112 and 111, transmitting and receiving port sections 122 and 121, transmitting and receiving port sections 132 and 131, and transmitting and receiving port sections 142 and 141 (see Fig. 12).

More specifically, the first transmission path port 110 is provided with the receiving port section 111 for receiving packets from the transmitters 1-n, and the transmitting port section 112 for transmitting packets to those transmitters 1-n. Similarly, the second transmission path port 120 is provided with the transmitting port section 122 and receiving port section 121 for transmitting and receiving packets to and from the transmitter 2-2. The third transmission path port 130 is provided with the transmitting port section 132 and receiving port section 131 for transmitting and receiving packets to and from the transmitter 2-4.

In the network 4 shown in Fig. 13, in order to perform communications from the transmitter 2-4 to the transmitter 2-2, in the relay transmitter 2-1 a data packet received from the transmission path port 130 is relayed to the transmission path port 120. To perform communications from the transmitter 2-4 to the transmitters 1-1 to 1-n, the data packet from the transmission path port 130 is also relayed to the

transmission path port 110. In other words, the data packet received by the receiving port section 131 of the transmission path port 130 is copied in the relay unit 153 of the transmitter 2-1 and relayed to the transmitters 1-1 to 1-n and to the transmitter 2-2.

Likewise, to perform communications from the transmitter 2-2 to the transmitter 2-4, a data packet received from the transmission path port 120 is relayed to the transmission path port 130. To perform communications from the transmitter 2-2 to the transmitters 1-1 to 1-n, the data packet from the transmission path port 120 is also relayed to the transmission path port 110. In other words, the data packet received by the receiving port section 121 of the transmission path port 120 is copied in the relay unit 152 and relayed to the transmitters 1-1 to 1-n and transmitter 2-4.

In addition, to perform communications from the transmitters 1-1 to 1-n to the transmitter 2-2, a data packet received from the transmission path port 110 is relayed to the transmission path port 120. To perform communications from the transmitters 1-1 to 1-n to the transmitter 2-4, the data packet from the transmission path port 110 is also relayed to the transmission path port 130. In other words, the data packet received by the receiving port section 111 of the transmission path port 110 is copied in the relay unit 151 and relayed to

the transmitter 2-4.

Another conventional transmitter adopting the above-described second transmission method is shown in Fig. 15. The transmitter, as with the transmitter shown in Fig. 12, includes receiving port sections 111, 121, 131, 141, transmitting port sections 112, 122, 132, 142, and a relay section 160.

Unlike the case of Fig. 12, the relay section 160 consists of a routing processing section 170 and a table register 180. The routing processing section 170 is equipped with a receiving part 171, a destination address extracting part 172, a judging part 173, and four transmitting parts 174 to 177. The table register 180 dynamically or statically stores a transmitting port number for relaying data for each destination address.

More specifically, in the routing processing section 170 of the transmitter adopting the second transmission method shown in Fig. 15, the destination address extracting part 172 extracts a destination transmitter address (destination address, DA) from the header of a data packet received by each of the receiving port sections 111, 121, 131, and 141. The judging part 173 extracts the number of the transmitting port section 112, 122, 132, or 142 connected with a destination transmitter, by referring to the statically or dynamically set table register 180. The judging part 173 further commands the transmitting parts 174, 175, 176, and 177

connected with the extracted transmitting port sections 112, 122, 132, and 142 to transfer data packets received by the receiving part 171.

For instance, in a network 4A with transmitters 5-1, 5-2, 6, 7, 8-1, 8-2, and 9 connected as shown in Fig. 16, when packets are transmitted by the above-described second transmission method, each of the transmitters 5-1, 5-2, 6, 7, 8-1, 8-2, and 9 is constructed as shown in Fig. 15.

Note that the network 4A has a redundant transmission path structure between the transmitters 7 and 9, which consists two routes. In the first route, packets are relayed to the transmitter 8-1 connected to the transmission path port 140. In the second route, packets are relayed to the transmitter 8-2 connected to the transmission path port 130.

In the relay transmitter 7, a data packet is relayed according to settings shown in Fig. 17 by the routing processing section 170 of the relay section 160. That is, a destination address (DA) in the header of a data packet (DP), received by the receiving port section 111 of the transmission path port 110 (see Fig. 15), is extracted by the destination address extracting part 172. When the extracted destination address is the address of the transmitter 9, that data packet DP is transferred to the transmission path port 140. In this way, the data packet DP received by the transmitter 7 is transferred to the

transmitter 9 via the transmitter 8-1.

Note that in order to construct a virtual local area network (VLAN), conventional network frame relay units store information about the corresponding
5 relationship between the address of a terminal in the destination of a network frame and a port connected to that terminal, and also store information about the corresponding relationship between the address of a terminal in the source of a network frame and a port
10 connected to a terminal in the destination of a network frame transmitted from the address of that source terminal (see Japanese Laid-Open Patent Publication No. HEI 9-186715).

In addition, in conventional packet switches,
15 if a packet is received, an IP flow table is searched for the IP source address and IP destination address of that packet in order to reduce microprocessor's routing load and security load. If the IP flow table has a corresponding IP flow, the packet is transferred to an appropriate output
20 port according to the routing process shown in the IP flow without being routed by a microprocessor (see Japanese Laid-Open Patent Publication No. 2000-295274).

However, the network 4 shown in Fig. 13 has the following problems when transmitting data packets by the
25 aforementioned first transmission method, using transmitters such as that shown in Fig. 12.

For instance, if a data packet is transmitted

from the transmitter 3-2 to the transmitter 1-1, the data packet is copied in the relay section 150 of the transmitter 2-1 and is relayed to the transmission path port 110 connected with the transmitters 1-1 to 1-n and to the transmission path port 120 connected with the transmitter 2-2. Because of this, the data packet relayed to the transmitter 2-2 returns to the transmitter 2-1 through the transmitters 2-3 and 2-4. Since the network portion 2 in the form of a ring has a closed transmission path, data packets can circulate through the ring path.

In the above-described case, the transmitter 2-1 relays a data packet toward the transmitter 2-2 as well as to the transmitter 1-1, so the data packet is also added onto the ring network portion 2. To avoid this, the number of hops (the number of relays from the transmitter 2-4 to the transmitter 1-1) is typically set to the header of a data packet, and a subtraction is made each time the data packet is relayed. After a predetermined number of relays, the data packet is discarded.

However, if a distance to the transmitter 1 (the number of hops) is long like the network 4 shown in Fig. 13 (particularly, if the value of n in reference numeral "1-n" is 4 or more, and 4 or more transmitters are connected in tandem), the number of hops at the transmitter 2-1 will reach a predetermined number.

If, in the network 4, a data packet is transmitted from the transmitters 1-1 to 1-n to the transmitters 2-2

to 2-4, data congestion will easily occur in the transmission path port 120 of the transmitter 2-1 because of the presence of data packets being circulated through the ring network portion 2, and consequently, an increase in traffic and the loss of transmitted packets will easily occur.

In the case where a network like Fig. 13 is constructed with transmitters having the same structure as that shown in Fig. 15, a data packet can be relayed only to a specified transmitter and therefore it is possible to solve the above-described problems, but since transmitting special data packets (such as multi-address transmission) is the equivalent of transmitting multi-destination packets, the same data congestion as the case of the above-described network 4 sometimes occurs. In this case, the problem of an increase in traffic and the loss of transmitted packets will easily arise and result in a reduction in the quality of transmission paths.

In addition, the network 4A shown in Fig. 16 has the following problems when transmitting data packets by the aforementioned second transmission method.

As shown in Fig. 16, both a data packet to be transmitted from the transmitter 5-1 to the transmitter 9 and a data packet to be transmitted from the transmitter 5-2 to the transmitter 9 have the same destination address, and the relay transmitter 7 relays these data packets through the same transmission path port without

discriminating between the two.

In that case, the two data packets are transferred to the transmitter 9 through the same route (connected to the transmission path port 130), even when
5 the path between the transmitters 7 and 9 has a redundant transmission path structure. Because of this, the network load on the route onto which data packets were transmitted is increased, and consequently, an increase in traffic and the loss of transmitted packets tend to take place.

10 On the other hand, even if the transmitter 7 relayed data packets to both ports in the manner shown in Fig. 12, the same data packet would be copied and transmitted and the traffic between the transmitters 7 and 9 would double.

15 The technique described in the aforementioned Japanese Laid-Open Patent Publication No. HEI 9-186715 is a technique to construct a virtual local area network (VLAN). Therefore, even if this technique is used in the transmitters of the networks 4 and 4A shown in Figs. 13
20 and 16, an increase in traffic and the loss of transmitted packets can not be prevented.

In addition, the technique described in the aforementioned Japanese Laid-Open Patent Publication No. 2000-295274 is a technique for reducing microprocessor's
25 routing load and security load. Therefore, even if this technique is employed in the transmitters of the networks 4 and 4A shown in Figs. 13 and 16, an increase in traffic

and the loss of transmitted packets can not be prevented.

SUMMARY OF THE INVENTION

5 The present invention has been made in view of the problems found in prior art. Accordingly, it is the object of the present invention to provide a transmitter and a transmission method that are capable of enhancing packet transmission efficiency, minimizing packet congestion, and improving the quality of transmission
10 paths.

To achieve this end and in accordance with the present invention, there are provided transmitters in a network. The transmitters have an individual specific address and are connected through different transmission
15 paths so that a packet with information about a source address is transmitted. Each transmitter comprises a plurality of transmission path ports respectively connected to the different transmission paths for receiving the packet, and a relay section for relaying
20 the received packet to a relay transmission path of the transmission paths by which the received packet reaches its destination. The relay section comprises a routing table and a router. In the routing table, information about the relay of the received packet to one of the
25 transmission path ports connected to the relay transmission path is stored, correlated with both a port identifier of each transmission path port and the source

address of the transmitter that transmitted the packet.
The router extracts the port identifier of the transmission
path port that received the packet, and the source address
contained in the received packet. The router routes the
5 received packet to the transmission path port connected
to the relay transmission path by referring to the table
for the extracted port identifier and source address.

In accordance with the present invention, there
is provided a packet transmission method for a network
10 where transmitters with an individual address are
connected through a transmission path so that a packet
with information about the address of a source transmitter
is transmitted from the source transmitter to a destination
transmitter. In a relay transmitter between the source
15 transmitter and the destination transmitter, the method
comprises (a) a port extracting step of extracting the
receiving port identifier in a packet received through
the transmission path, (b) an address extracting step of
extracting a source address contained in the received
20 packet, and (c) a routing step of routing the received
packet, based on the extracted receiving port identifier
and the extracted source address.

Thus, according to the present invention, the
table of the relay section stores information about the
25 relay of a received packet to a transmission path port
connected with a relay transmission path by which the
received packet reaches its destination, and correlates

the relay information with both the port identifier of each transmission path port that receives a packet and the address of a source transmitter that transmitted the received packet. The router routes a received packet by referring to the above-described table, based on the port identifier of a transmission path port that received a packet and on the source address contained in the received packet. Therefore, packet transmission efficiency can be enhanced, data congestion can be minimized, and the quality of transmission paths can be improved.

In addition, the table stores information that a received packet is not relayed if it circulates through a network, and information that a received packet is relayed if it does not circulate through a network. In this way, whether a data packet transmitted from the transmitter is transmitted to an individual address or multiple addresses, the circulation of the data packet can be prevented in an interval through which a data packet can circulate, such as a ring network, a mesh network, etc. Therefore, data congestion can be minimized, a reduction in traffic can be realized, and the quality of transmission paths can be enhanced.

In addition, in the case where a path to a destination transmitter is divided into a plurality of paths and has a redundant structure, transmission path ports to relay a received packet are assigned by the table so that many of them are not connected only to one of the

paths. Thus, by efficiently utilizing the redundant structure, an increase in the networking load on the side where a data packet is transmitted can be prevented. In addition, an increase in traffic and the loss of transmitted
5 packets can be minimized and packet transmission efficiency can be exponentially enhanced.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be described in
10 further detail with reference to the accompanying drawings wherein:

FIG. 1 is a block diagram showing a transmitter constructed in accordance with a preferred embodiment of the present invention;

15 FIG. 2 is a perspective view showing a first network constructed of transmitters with the same structure as that of the transmitter shown in FIG. 1;

FIG. 3 is a diagram showing how the table register of the transmitter shown in FIG. 2 is set;

20 FIG. 4 is a block diagram showing how data packets are relayed in the network shown in FIG. 2;

FIG. 5 is a diagram showing how the table register of the transmitter shown in FIG. 2 is set;

25 FIG. 6 is a block diagram showing how data packets are relayed in the network shown in FIG. 2;

FIG. 7 is a diagram showing how the table register of the transmitter shown in FIG. 2 is set;

FIG. 8 is a perspective view showing a second network constructed of transmitters with the same structure as that of the transmitter shown in FIG. 1;

FIG. 9 is a diagram showing how the table register of the transmitter shown in FIG. 8 is set;

FIGS. 10(a) and 10(b) are diagrams showing how the table register of the transmitter shown in FIG. 8 is set;

FIG. 11 is a perspective view showing a third network constructed of transmitters with the same structure as that of the transmitter shown in FIG. 1;

FIG. 12 is a block diagram showing a conventional transmitter;

FIG. 13 is a perspective view showing a conventional network that consists of transmitters such as that shown in FIG. 12;

FIG. 14 is a block diagram showing how data packets are delayed in the network of FIG. 13;

FIG. 15 is a block diagram showing another conventional transmitter;

FIG. 16 is a perspective view showing another conventional network that consists of transmitters such as the one shown in FIG. 15; and

FIG. 17 is a block diagram showing how data packets are delayed in the network of FIG. 16.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Embodiments of the present invention will hereinafter be described in detail with reference to the drawings.

[A] Description of a Transmitter According to
5 a Preferred Embodiment of the Present Invention

Fig. 1 shows a transmitter 60 constructed in accordance with a preferred embodiment of the present invention. The transmitter 60 includes receiving port sections 11, 21, 31, 41, transmitting port sections 12,
10 22, 32, 42, and a relay section 50. A plurality of transmitters with a specific address such as the transmitter 60 are connected through a transmission path such as optical fiber, and are used in a network where a packet with address information about a source
15 transmitter is transmitted.

That is, by employing transmitters such as the transmitter 60 shown in Fig. 1, networks 64 and 64A can be constructed as shown in Figs 2 and 7. In addition, in a network, in which a plurality of transmitters with
20 a structure like that shown in Fig. 1 are connected through optical fiber, the above-described packet can be multiplexed to a SONET/SDH frame and transmitted.

In Fig. 1, the receiving port sections 11, 21, 31, and 41 consist of O/E converters 13, 23, 33, 43, first-in
25 first-out (FIFO) memories 15, 25, 35, 45, and reception controllers 14, 24, 34, 44, respectively. The O/E converters 13, 23, 33, and 43 convert an optical signal

input via a transmission path into an electrical signal
and also separate a multiplexed signal into packet signals.
The FIFO memories 15, 25, 35 and 45 hold the converted
electrical signal temporarily. The reception
5 controllers 14, 24, 34, and 44 control the writing and
reading of data with respect to the FIFO memories 15, 25,
35 and 45.

The transmitting port sections 12, 22, 32, and
42 consist of FIFO memories 17, 27, 37, 47, transmission
10 controllers 16, 26, 36, 46, and E/O converters 18, 28,
38, 48, respectively. The FIFO memories 17, 27, 37, and
47 temporarily hold transmitted signals, output from the
relay section 50. The transmission controllers 16, 26,
36, and 46 control the writing and reading of data with
15 respect to the FIFO memories 17, 27, 37 and 47. The E/O
converters 18, 28, 38, and 48 multiplex transmitted packet
signals read out from the transmission controllers 16,
26, 36, and 46, and convert the multiplexed electrical
signal into an optical signal.

20 The transmitter 60 shown in Fig. 1 is provided
with 4 (four) transmission path ports 10, 20, 30, and 40,
which are connected to 4 (four) transmitters through
optical fiber paths. These transmission path ports 10,
20, 30, and 40 have port numbers as specific port identifiers,
25 respectively.

The above-described receiving port section 11
and transmission port section 12 constitute the first

transmission path port 10. The above-described receiving
port section 21 and transmission port section 22 constitute
the second transmission path port 20. The above-described
receiving port section 31 and transmission port section
5 32 constitute the third transmission path port 30. The
above-described receiving port section 41 and transmission
port section 42 constitute the fourth transmission path
port 40. In other words, the transmission path ports 10,
20, 30, and 40 serve as ports that are connected to the
10 transmission paths of a network.

In the relay section 50, the transmission path
ports 10, 20, 30, and 40 receive packets and retransmit
them onto relay transmission paths by which the received
packets travel to their destinations. The relay section
15 50 consists of a routing section 51 and a table register
52, which are different in structure from those shown in
Fig. 12.

The table register 52 serves as a table that
stores information about the relay of a received packet
20 to a transmission path port connected with a relay
transmission path, correlated with both the receiving port
number (port identifier) of each transmission path port
that receives a packet, and the address of a source
transmitter (source address) contained in the header of
25 a received packet. In the preferred embodiment, the table
register 52 can also dynamically or statically set the
identification number (transmitting port number) of a

transmitting port section (relay port section) for each destination address, along with the above-described source address and receiving port number.

5 The routing section 51 extracts the port identifier of a transmission path port that received a packet, and the source address of a source transmitter contained in the received packet. By searching the table register 52 for the extracted port identifier and source address, the routing section 51 also retransmits the
10 received packet to a transmission path port connected with a relay transmission path by which the received packet travels to its destination. To perform these functions, the routing section 51 is equipped with a receiving part 53, a destination address (DA) extracting part 54, a source
15 address (SA) extracting part 55, a receiving port extracting part 56, and a routing processing part 59.

 The receiving part 53 receives packets from the receiving controllers 14, 24, 34, and 44 in a predetermined sequence. The destination address extracting part 54
20 extracts the destination address of a destination transmitter from a packet signal received by the receiving part 53. The source address extracting part 55 extracts the source address of a source transmitter from a packet signal received by the receiving part 53.

25 Note that since a destination address and a source address can be contained in the header of a packet, the destination address extracting part 54 and the source

address extracting part 55 can extract a destination address and a source address from the content of the packet header.

5 For a received packet signal from which a source address and a destination address were extracted by the destination address extracting part 54 and the source address extracting part 55, the receiving port extracting part 56 extracts the receiving port number of the receiving port section 11, 21, 31, or 41 to which the received packet
10 signal was input as a frame signal. That is, the receiving port extracting part 56 serves as a receiving port identifier extracting part that extracts the receiving port number (receiving port identifier) of the receiving port 10, 20, 30, or 40 that received a packet through a
15 transmission path.

In response to the receiving port number (receiving port identifier) from the receiving port extracting part 56 and the source address of a source transmitter from the source address extracting part 55,
20 the routing processing part 59 searches the table register 52 for the receiving port number and the source address, and then routes the received packet. To perform this routing function, the routing processing part 59 is equipped with a judging part 57 and transmitting parts
25 58-1 to 58-4.

The judging part 57 judges whether a received packet is relayed by referring to the table register 52

with the receiving port number from the receiving port
extracting part 56 and the address of a source transmitter
from the source address extracting part 55 as keys, and
selectively decides the transmitting port section 12, 22,
5 32, or 42 (which becomes a relay port) for each received
packet.

The judging part 57 can also decide the
transmitting port section 12, 22, 32, or 42 (to which a
packet is transferred) by referring to the table register
10 52, based on the destination address from the destination
address extracting part 54, along with the receiving port
number from the receiving port extracting part 56 and the
source address from the source address extracting part
55.

15 If the transmitting port section 12, 22, 32,
or 42 is decided in the aforementioned manner, the judging
part 57 commands the transmitting part (58-1, 58-2, 58-3,
or 58-4) connected to the decided transmitting port section
(12, 22, 32, or 42) to output a received packet to the
20 subsequent stage.

That is, the transmitting parts 58-1 to 58-4
(which serve as an assigning part) assign a received packet
from the receiving part 53, to the transmitting port section
12, 22, 32, or 42, based on the result of judgement from
25 the routing part 57.

More specifically, a received packet from the
receiving part 53 is transferred to the subsequent stage

from the transmitting part (58-1, 58-2, 58-3, or 58-4) connected to the transmitting port section (12, 22, 32, or 42) in which it was judged that a received packet is relayed. From the transmitting part (58-1, 58-2, 58-3, or 58-4) connected to the transmitting port section (12, 22, 32, or 42) in which it was judged that a received packet is not relayed, no packet is transferred to the subsequent stage.

Therefore, in response to a command from the above-described judging part 57, the transmitting part (58-1, 58-2, 58-3, or 58-4), connected to the transmitting port section (12, 22, 32, or 42) decided as a port to which a received packet is transferred, transmits a received packet (from the receiving section 53) to the subsequent transmission controller (16, 26, 36, or 46).

Therefore, in a network where a plurality of transmitters like the transmitter 60 with such a structure are connected through transmission paths, a packet from a source transmitter to a destination transmitter is relayed according to the following routing by a relay transmitter.

Initially, if a multiplexed frame is received as an optical signal from any of the receiving port sections 11, 21, 31, and 41 of the transmission path ports 10, 20, 30, and 40, the O/E converters 13, 23, 33, and 43 of the receiving port sections 11, 21, 31, and 41 convert the multiplexed signal into an electrical signal and separates

it into packet signals. In the reception controllers 14, 24, 34, 44 and FIFO memories 15, 25, 35, 45, the received packet signals are output to the receiving part 53 in a predetermined sequence.

5 In the receiving port extracting part 56, a receiving port identifier in the packet received by the receiving part 53 is extracted (receiving port extracting step), and in the source address extracting part 55, a source address contained in the received packet is
10 extracted (source address extracting step).

 Based on the receiving port identifier from the receiving port extracting part 56 and the source address from source address extracting part 55, the received packet is routed by the judging part 57 and the transmitting parts
15 58-1 to 58-4 (routing step).

 In the judging part 57, the relay of a received packet is judged based on the receiving port identifier extracted by the receiving port extracting step and the source address extracted by the source address extracting
20 step (judgement step). In the transmitting parts 58-1 to 58-4, if it is judged that a received packet is relayed, that packet is assigned to the transmitting port section 12, 22, 32, or 42. On the other hand, if it is judged that a received packet is not relayed, information is sent
25 that a received packet is not relayed, and the assignment of a received packet to the correlated transmitting port section 12, 22, 32, or 42 is not performed (assignment

step).

Thereafter, the transmission controllers 16, 26, 36, and 46, which received a packet signal from any of the transmitting parts 58-1 to 58-4, perform first-in first-out control in cooperation with the FIFO memories 17, 27, 37, and 47. In the E/O converters 18, 28, 38, and 48, packet signals from the transmission controllers 16, 26, 36, and 46 are framed and converted into an optical signal. This makes it possible to transmit a framed packet signal toward a destination transmitter through a transmission path (optical fiber).

Now, a description will be given of a first network 64 (see Fig. 2) and a second network 64A (see Fig. 8), constructed of transmitters such as the transmitter 60.

[B] Description of a First Network Constructed According to the Preferred Embodiment of the Present Invention

Fig. 2 depicts a first network 64 constructed of transmitters 61-1 to 61-n, 62-1 to 62-4, 63-1, and 63-2 with the same structure as that of the transmitter 60 shown in Fig. 1. The transmitters 61-1 to 61-n, 62-1 to 62-4, 63-1, and 63-2 constituting the first network 64 shown in Fig. 2 have specific addresses and are connected through optical-fiber transmission paths.

In the first network 64 shown in Fig. 2, the transmitters 61-1 to 61-n, 62-1 to 62-4, 63-1, and 63-2

are arranged the same as the network 4 shown in Fig. 13,
but the first network 64 is constructed to prevent
congestion, an increase in traffic, and the loss of
transmitted packets by eliminating a data packet
5 circulating through a closed path to prevent data from
being congested at the transmission path port of a certain
transmitter.

The network 64 consists of a first network
portion 61, a second network portion 62, and a third network
10 portion 63. In the first network portion 61, transmitters
61-1 to 61-n are connected in tandem. In the second network
portion 62, transmitters 62-1 to 62-4 are connected in
duplex ring form. In the third network portion 63,
transmitters 63-1 and 63-2 are connected in tandem. The
15 transmitter 61-n is connected to the transmitter 62-1,
so the first and second network portions 61 and 62 are
connected together. The transmitter 62-4 is connected
to the transmitter 63-1, so the second and third network
portions 2 and 3 are connected together.

20 As with the network portion 2 of the network
4 shown in Fig. 13, the second network portion 62 consisting
of transmitters 62-1 to 62-4 is an interval through which
data packets can circulate. However, as described above,
the second network portion 62 is constructed so packet
25 circulation does not occur. For instance, a received
packet is relayed as shown in Figs. 3 and 5 in accordance
with the table register 52 of the relay transmitter 62-1

and 62-4.

More specifically, if the table register 52 of the transmitter 62-1 is set as shown in Fig. 3, data packets input via the receiving port sections 11 to 31 of the transmission path ports 10 to 30 are routed by the routing section 51 so the packets do not circulate through the ring network portion 62.

Among data packets input via the receiving port section 11 of the transmission path port 10 connected with the transmission path between the port 10 and the transmitter 61-n (see D10 in Fig. 4), the data packets with the source addresses of the transmitters 61-1 to 61-n that are on the path connected to the transmission path port 10 are relayed (○), whereas the data packets with the source addresses of the transmitters 62-1 to 62-4, 63-1, and 63-2 other than those are not relayed (×).

Among data packets input via the receiving port section 21 of the transmission path port 20 connected with the transmission path between the port 20 and the transmitter 62-2 (see D20 in Fig. 4), the data packets with the source addresses of the transmitters 62-2 to 62-4, 63-1, and 63-2 that are on the paths connected to the transmission path port 20 are relayed (○), whereas the data packets with the source addresses of the transmitters 61-1 to 61-n and 62-1 other than those are not relayed (×).

Among data packets input via the receiving port

section 31 of the transmission path port 30 connected with the transmission path between the port 30 and the transmitter 62-4 (see D30 in Fig. 4), the data packets with the source addresses of the transmitters 62-2 to 62-4, 63-1, and 63-2 that are on the paths connected to the transmission path port 30 are relayed (○), whereas the data packets with the source addresses of the transmitters 61-1 to 61-n and 62-1 other than those are not relayed (×).

Furthermore, if the table register 52 of the transmitter 62-4 is set as shown in Fig. 5, data packets input via the receiving port sections 11 to 31 of the transmission path ports 10 to 30 are relayed so that packets do not circulate through the ring network portion 62.

That is, among data packets input via the receiving port section 11 of the transmission path port 10 connected with the transmission path between the port 10 and the transmitter 62-1 (see DD10 in Fig. 6), the data packets with the source addresses of the transmitters 61-1 to 61-n and 62-1 to 62-3 that are on the paths connected to the transmission path port 10 are relayed (○), whereas the data packets with the source addresses of the transmitters 62-4, 63-1, and 63-2 other than those are not relayed (×).

Among data packets input via the receiving port section 21 of the transmission path port 20 connected with the transmission path between the port 20 and the

transmitter 62-3 (see DD20 in Fig. 6), the data packets with the source addresses of the transmitters 61-1 to 61-n and 62-1 to 62-3 that are on the paths connected to the transmission path port 20 are relayed (○), whereas the
5 data packets with the source addresses of the transmitters 62-4, 63-1, and 63-2 other than those are not relayed (×).

Among data packets input via the receiving port section 31 of the transmission path port 30 connected with the transmission path between the port 30 and the
10 transmitter 63-1 (see DD30 in Fig. 6), the data packets with the source addresses of the transmitters 63-1 and 63-2 that are on the path connected to the transmission path port 30 are relayed (○), whereas the data packets with the source addresses of the transmitters 61-1 to 61-n
15 and 62-1 to 62-4 other than those are not relayed (×).

In other words, in the relay transmitters 62-1 and 62-4 to which a plurality of paths are connected through the different transmission path ports, data packets received via the transmission path ports 10 to 30 are relayed
20 when the source addresses in those packets are the same as those of the transmitters on the paths connected to transmission path ports 10 to 30 and not relayed when the source addresses in those packets are the same as those of the transmitters (including a self-transmitter) that
25 are not on the path connected to the transmission path port 10.

In the transmitters 61-1 to 61-n, 62-2, 62-3,

63-1, and 63-2 other than the above-described transmitters
62-1 and 62-4, data packets are relayed according to the
table register 52 set as shown in Fig. 7. Among data packets
input via the receiving port sections 11 to 31 of the
transmission path port 10 to 30, the data packets with
5 the source addresses of the transmitters other than
self-transmitters are relayed (○), whereas the data
packets with the source addresses of self-transmitters
are not relayed (×).

10 In other words, the table registers 52 of the
transmitters 61-1 to 61-n, 62-1 to 62-4, 63-1, and 63-2
of the network 64 store information about the relay of
a received packet correlated with both the receiving port
identifier and the source address. For example, the table
15 registers 52 store information that a received packet is
not relayed (×) if it circulates through the network 64
(particularly the network portion 62), and information
that a received packet is relayed (○) if it does not
circulate through the network 64.

20 In this way, data packets that pass through the
path of the network portion 62 from any of the transmitters
62-1 to 62-4 are discarded in at least the source
transmitters when they have returned, so they do not
circulate through the network portion. For example, a
25 data packet from the transmitter 62-1 that is a source
transmitter is relayed to the transmitters 62-2 and 62-3
and to the transmitter 62-4, but in the source transmitter

62-1, the data packet relayed from the transmitter 62-4 is discarded without being transferred to the transmitter 62-2.

5 In the transmitter 62-4, a data packet transmitted from the transmitter 63-1 is relayed to both the transmission path port on the side of the transmitter 62-1 and the transmission path port on the side of the transmitter 62-3. However, in the case where the data packet from the transmitter 63-1 circulates through the
10 network portion 62 and is again received by the transmission path ports 10 and 20 of the transmitter 62-4, this data packet is not relayed to the subsequent stage, and therefore data can be discarded without being circulated through the network portion 62 again.

15 Therefore, in the transmitter 62-4, the data packets from the transmitters 62-1, 62-2, and 62-3 in the ring network portion 62 are relayed and a data packet being circulated through the network portion 62 can be reliably prevented from being circulated again. Therefore, even
20 in the case of data packets by multi-address communications, data communications to transmitters on a network can be reliably performed and congestion due to packet circulation can be avoided.

Note that an example of the above-described data
25 packets by multi-address communications is network supervisory packets that are contained in a multiplexed frame and transmitted to the transmitters 61-1 to 61-n,

62-1 to 62-4, and 63-1, through a network management server (not shown) included in the transmitter 63-2.

Thus, according to the preferred embodiment of the present invention, the table register 52 of the relay section 50 stores information about the relay of a received packet to a transmission path port connected with a relay transmission path by which the received packet reaches its destination, and correlates the relay information with both the port identifier of each transmission path port that receives a packet and the address of a source transmitter that transmitted the received packet. The routing section 51 routes a received packet by referring to the above-described table register 52, based on the port identifier of a transmission path port that received a packet and on the source address contained in the received packet. Therefore, packet transmission efficiency can be enhanced, data congestion can be minimized, and the quality of transmission paths can be improved.

In addition, according to the preferred embodiment of the present invention, the network 64 shown in Fig. 2 is constructed of transmitters with the same structure as that of the transmitter 60, and the table register 52 stores information that a received packet is not relayed if it circulates through a network, and information that a received packet is relayed if it does not circulate through a network. In this way, whether a data packet transmitted from the transmitter 63-1 is

transmitted to an individual address or multiple addresses,
the circulation of the data packet can be prevented in
an interval through which a data packet can circulate,
such as a ring network, a mesh network, etc. Therefore,
5 data congestion can be minimized, a reduction in traffic
can be realized, and the quality of transmission paths
can be enhanced.

[C] Description of a Second Network Constructed
According to the Preferred Embodiment of the Present
10 Invention

Fig. 8 depicts a second network 64A constructed
of transmitters 61-1 to 61-n, 62-1 to 62-4, 63-1, and 63-2
with the same structure as that of the transmitter 60 shown
in Fig. 1.

15 In the network 64A shown in Fig. 8, the
transmitters 65-1, 65-2, 66, 67, 68-1, 68-2, and 69 are
arranged the same as those of the network 4A shown in Fig.
16. The network 64A, as with the network 4A, has a redundant
transmission structure between the transmitters 67 and
20 69. That is, the transmission path port 20 of the
transmitter 67 is connected to the transmitter 69 via the
transmitter 68-1, and the transmission path port 30 of
the transmitter 67 is connected to the transmitter 69 via
the transmitter 68-2.

25 If each of the transmitters 65-1, 65-2, 66, 67,
68-1, 68-2, and 69 is constructed as shown in Fig. 1, and
data packets are transmitted via the above-described

redundant transmission structure, transmission paths can be assigned according to source addresses.

For example, consider a data packet whose destination address is the transmitter 69, input via the receiving port section 11 of the transmission path port 10 of the transmitter 67. To assign the relay transmission path ports 20 and 30 by the transmitting parts 58-1 to 58-4 (see Fig. 1) in accordance with the source address extracted from that data packet, data packets are relayed as shown in Fig. 9 by the table register 52 of the transmitter 67.

That is, for the data packet whose source address is the transmitter 65-1, input via the receiving port section 11 of the transmission path port 10 of the transmitter 67, a relay through the transmission port 20 is performed (○), whereas a relay through the transmission port 30 is not performed (×). For a data packet whose source address is the transmitter 65-2, a relay through the transmission port 20 is not performed (×), whereas a relay through the transmission port 30 is performed (○).

In this way, in the relay transmitter 67, the data packet that is transmitted from the transmitter 65-1 to the transmitter 69 is relayed to the transmitter 69 through the transmitter 68-1, based on the source address and the receiving port identifier in the header of that data packet. The data packet that is transmitted from the transmitter 65-2 to the transmitter 69 is relayed to

the transmitter 69 through the transmitter 68-1.

In other words, in the case where a path to the transmitter 69 (destination) is divided into a plurality of paths (in the case of Fig. 8, two paths) and has a redundant structure, a transmission port section correlated with both a receiving port identifier and a source address is assigned according to the table register 52 by the routing section 51 so that many data packets are not relayed only to one of the paths.

In the network 64A shown in Fig. 8, when data packets are transmitted from the transmitters 65-1 and 65-2 to the transmitter 69, the following routing is performed in the transmitter 67.

As shown in Fig. 1, in the routing section 51 of the transmitter 67, a destination address and a source address in the header of a data packet received through the receiving port section 11 of the transmission path port 10 are extracted by the destination address extracting part 54 and the source address extracting part 55.

Based on the identification number of a receiving port section extracted by the receiving port extracting part 56 along with the extracted destination address and source address, the judging part 57 determines the transmission path port 20 or 30 for each data packet by referring to the content of the table register 52. Based on the determined transmission path ports 20 and 30, the judging part 57 gives commands to the transmitting parts

58-1 to 58-4. In response to these commands, the transmitting parts 58-1 to 58-4 perform the assignment of data packets to the determined transmission path ports 20 and 30.

5 In this way, a data packet from the transmitter 65-1 to the transmitter 69 is transmitted through the transmission port section 22 of the transmission path port 20, so it is relayed to the transmitter 69 via the transmitter 68-1. A data packet from the transmitter 65-2
10 to the transmitter 69 is transmitted through the transmission port section 32 of the transmission path port 30, so it is relayed to the transmitter 69 via the transmitter 68-2.

 Thus, according to the preferred embodiment of
15 the present invention, the transmitters 65-1, 65-2, 66, 67, 68-1, 68-2, and 69 are equipped with the relay section 50, which has the routing section 51 and the table register 52. Therefore, as in the network 64 shown in Fig. 2, packet transmission can be enhanced, data congestion can be
20 minimized, and the quality of transmission paths can be improved.

 In addition, in the case where the network 64A such as that shown in Fig. 8 is constructed of transmitters with the same structure as that of the transmitter 60,
25 and a path from the transmitter 67 to the transmitter 69 (destination) is divided into a plurality of paths and has a redundant structure, transmission path ports to relay

a received packet are assigned by the table register 52 so that many of them are not connected only to one of the paths. Thus, by efficiently utilizing the redundant transmission path structure between the transmitters 67 and 69, an increase in the networking load on the side where a data packet is transmitted can be prevented. In addition, an increase in traffic and the loss of transmitted packets can be minimized and packet transmission efficiency can be further enhanced.

10 [D] Others

In the transmitters constituting the networks 64 and 64A shown in Figs. 2 and 8, the table register 52 stores information about the relay of a packet for each relay transmission path port (which delays a packet to its destination), and correlates the relay information with both a source address extracted by the source address extracting part 55 and a receiving port identifier extracted by the receiving port extracting part 56. However, the table register 52 according to the present invention is also capable of employing an index for other routing in combination with the above-described source address and receiving port identifier. In such a case, in addition to the above-described advantages of the present invention, the degree of freedom of packet transmission between transmitters can be enhanced.

For example, as shown in Fig. 10(a), the relay of a packet can also be stored for each transmission path

port (which relays a packet to its destination), correlated with a combination of the above-described source address and receiving port identifier and a destination address. In this case, as shown in Fig. 10(a), even when a received
5 packet has the same source address and the same receiving port identifier, it is relayed if its destination is a transmitter m1, but it is not relayed if its destination is a transmitter m2.

In this case, as shown in Fig. 10(b), all
10 transmission path ports may be designated as a transmission path port which delays a received packet to its destination (don't care). That is, for data packets with the same source address and receiving port identifier, a data packet whose destination address is m1 is relayed through all
15 transmission path ports 10, 20, 30, and 40, but a data packet whose destination address is m2 is not relayed.

In the transmitter according to the preferred embodiment, while the ring network portion 62 shown in Fig. 2 has been described as a path through which a received
20 packet circulates, the present invention is not limited to this example. The present invention is also applicable to a mesh network portion through which a received packet can circulate.

In addition, the present invention is not to
25 be limited to the forms of the networks shown in Figs. 2 and 8. In various forms of networks, which have a packet circulating path or a redundant path structure, other than

those, the present invention possesses the above-described advantages.

For instance, a network 90 with transmitters 71 to 89 can be constructed as shown in Fig. 11. In this network 90, data packets can circulate through a network portion consisting of transmitters 80 to 85 and a network portion consisting of transmitters 86 to 89, but when the transmitters 71 to 89 are constructed as shown in Fig. 1, packet circulation can be prevented in the above-described network portions.

In the case where the path from the transmitter 80 to the transmitter 83 has a redundant structure, data packets can be transmitted according to source transmitters (e.g., transmitters 71 to 79 and 86 to 89) by the contents of the table registers 52 of the relay transmitters 81, 82, 84, and 85 so that many of them are not relayed only to a certain path.

In the preferred embodiment of the present invention, while a multiplexed signal is transmitted and received between transmitters, the present invention is not limited to this example. It is also applicable to transmitters that constitute a network to which multiplexing protocols do not apply.

While the present invention has been described with reference to the preferred embodiments thereof, the invention is not to be limited to the details given herein, but may be modified within the scope of the invention

hereinafter claimed.

Finally, it is possible to manufacture the transmitter of the present invention by the embodiments disclosed as described above.